

## ABSTRACT

This report summarizes research conducted at Iowa State University on behalf of the Iowa Department of Transportation, focusing on the volumetric state of hot-mix asphalt (HMA) mixtures as they transition from stable to unstable configurations. This has traditionally been addressed during mix design by meeting a minimum voids in the mineral aggregate (VMA) requirement, based solely upon the nominal maximum aggregate size without regard to other significant aggregate-related properties. The goal was to expand the current specification to include additional aggregate properties, e.g., fineness modulus, percent crushed fine and coarse aggregate, and their interactions. The work was accomplished in three phases: a literature review, extensive laboratory testing, and statistical analysis of test results.

The literature review focused on the history and development of the current specification, laboratory methods of identifying critical mixtures, and the effects of other aggregate-related factors on critical mixtures.

The laboratory testing involved three maximum aggregate sizes (19.0, 12.5, and 9.5 millimeters), three gradations (coarse, fine, and dense), and combinations of natural and manufactured coarse and fine aggregates. Specimens were compacted using the Superpave Gyratory Compactor (SGC), conventionally tested for bulk and maximum theoretical specific gravities and physically tested using the Nottingham Asphalt Tester (NAT) under a repeated load confined configuration to identify the transition state from sound to unsound.

The statistical analysis involved using ANOVA and linear regression to examine the effects of identified aggregate factors on critical state transitions in asphalt paving mixtures and to develop predictive equations.

The results clearly demonstrate that the volumetric conditions of an HMA mixture at the stable-unstable threshold are influenced by a composite measure of the maximum aggregate size and gradation and by aggregate shape and texture. The currently defined VMA criterion, while significant, is seen to be insufficient *by itself* to correctly differentiate sound from unsound mixtures. Under current specifications, many otherwise sound mixtures are subject to rejection solely on the basis of failing to meet the VMA requirement. Based on the laboratory data and statistical analysis, a new paradigm to volumetric mix design is proposed that explicitly accounts for aggregate factors (gradation, shape, and texture).